



Trigger Cost & Schedule

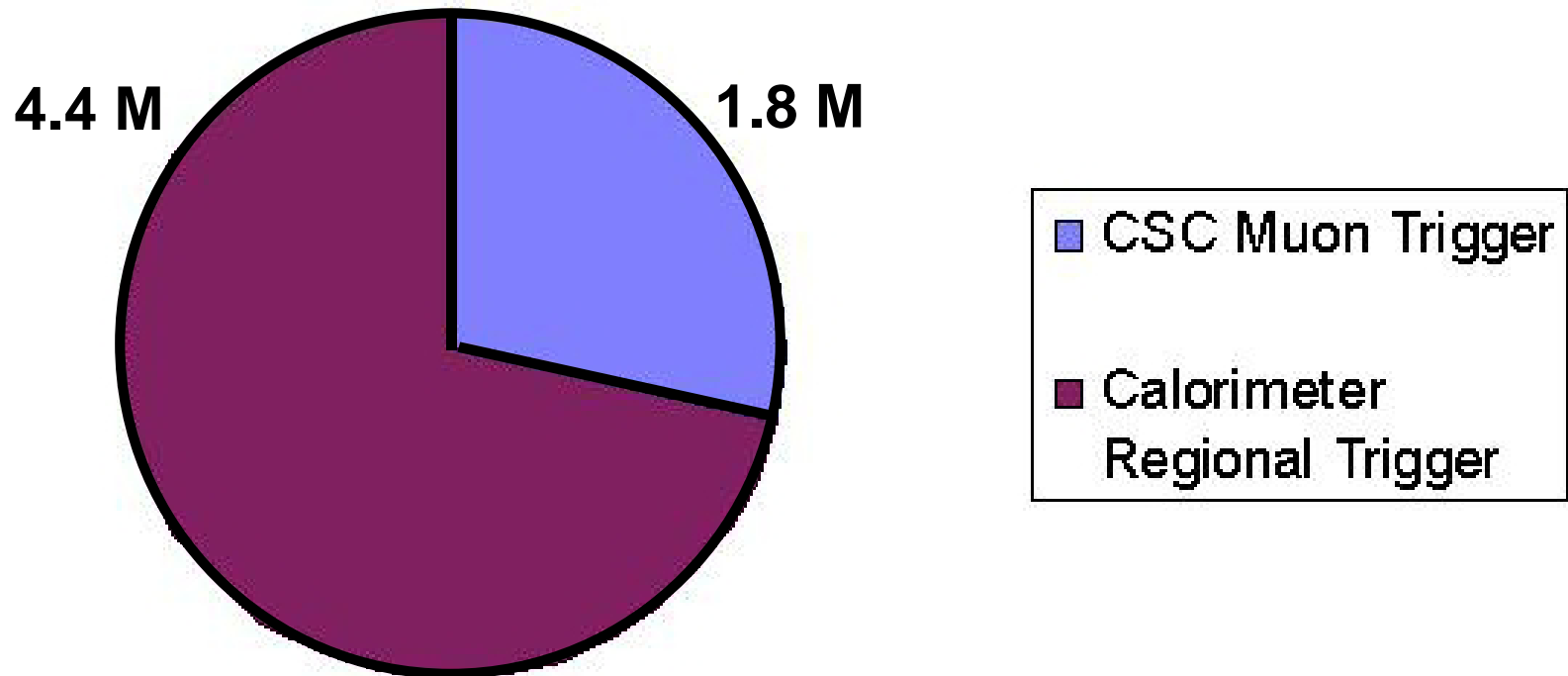
**Wesley Smith, *U. Wisconsin*
CMS Trigger Project Manager**

**DOE/NSF Review
February 18, 1999**



Trigger Costs at L4

Trigger, L4 Costs -- 6.2 M





Calorimeter Trig. Costs at L5

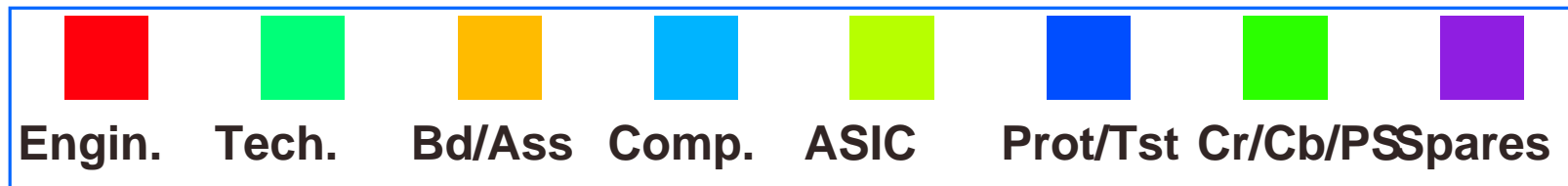
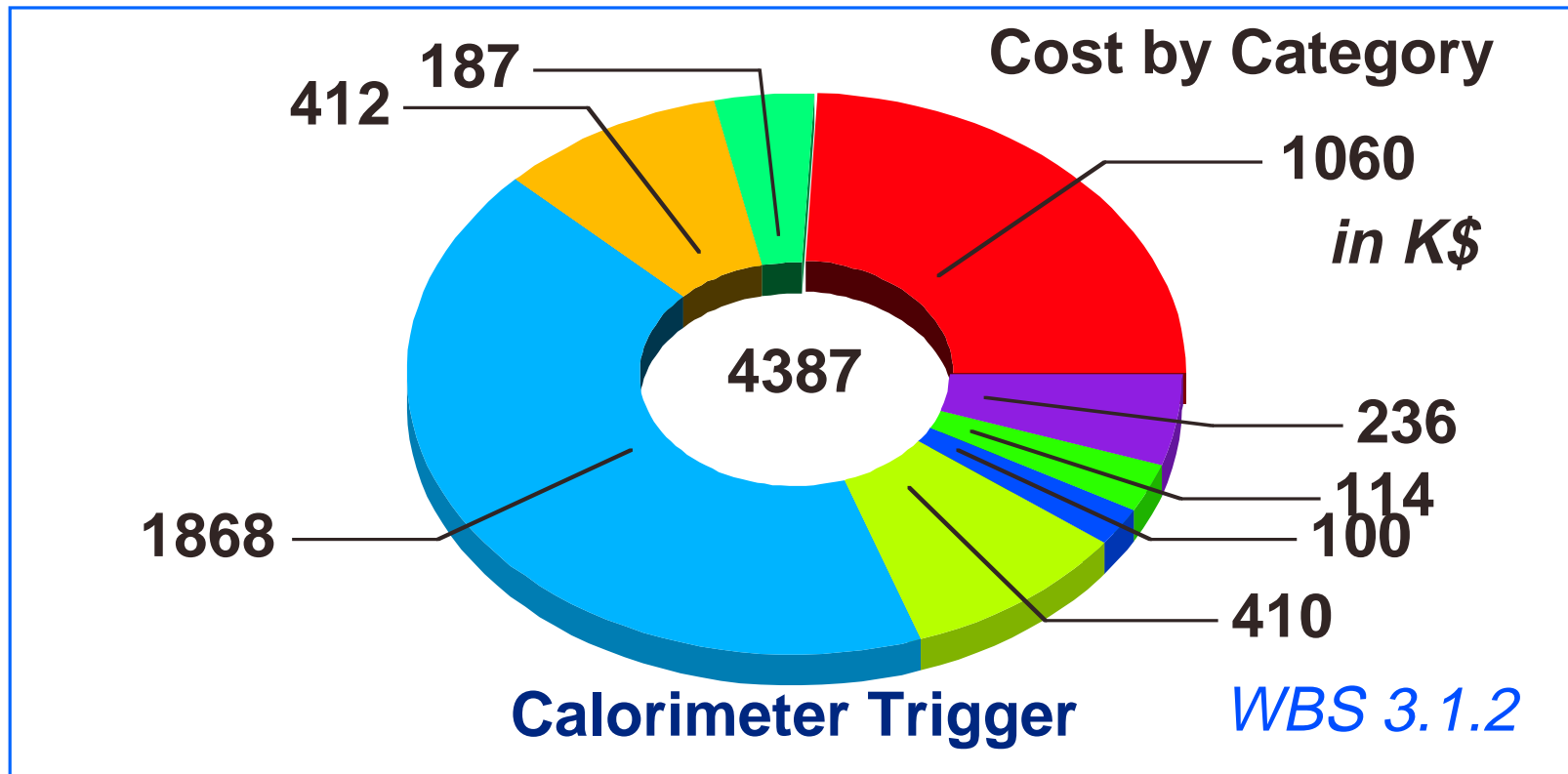
WBS	ITEM	BASE(K\$)	Cont(%)	TOTAL (K\$)
3.1.2	Cal.Regional Trigger	4,388	50	6581
3.1.2.1	Prototypes	441	46	643
3.1.2.2	Preproduction ASICs	553	47	811
3.1.2.3	Test Facilities	78	50	117
3.1.2.4	Power Supplies	82	30	106
3.1.2.5	Crates	35	30	45
3.1.2.6	Backplane	194	54	299
3.1.2.7	Clock & Control Card	132	40	185
3.1.2.8	Receiver Card	1,670	54	2571
3.1.2.9	Electron ID Card	744	50	1116
3.1.2.10	Jet Summary Card	170	50	254
3.1.2.11	Cables	7	30	9
3.1.2.12	DAQ Processor			
3.1.2.13	Crate Monitor Card			
3.1.2.14	Trigger Tests	282	50	423
3.1.2.15	Project Management			

Changes since May 1998 Review (above):

- Added (WBS 3.1.2.1.8) Prototype Crate Test (Item from Review): 33.5K
- Added (WBS 3.1.2.1.9) Serial Link Prototype (HCAL->Trigger): 99.6K
- Added 1 FTE engineering for above from U. Wisc. Physical Sciences Lab



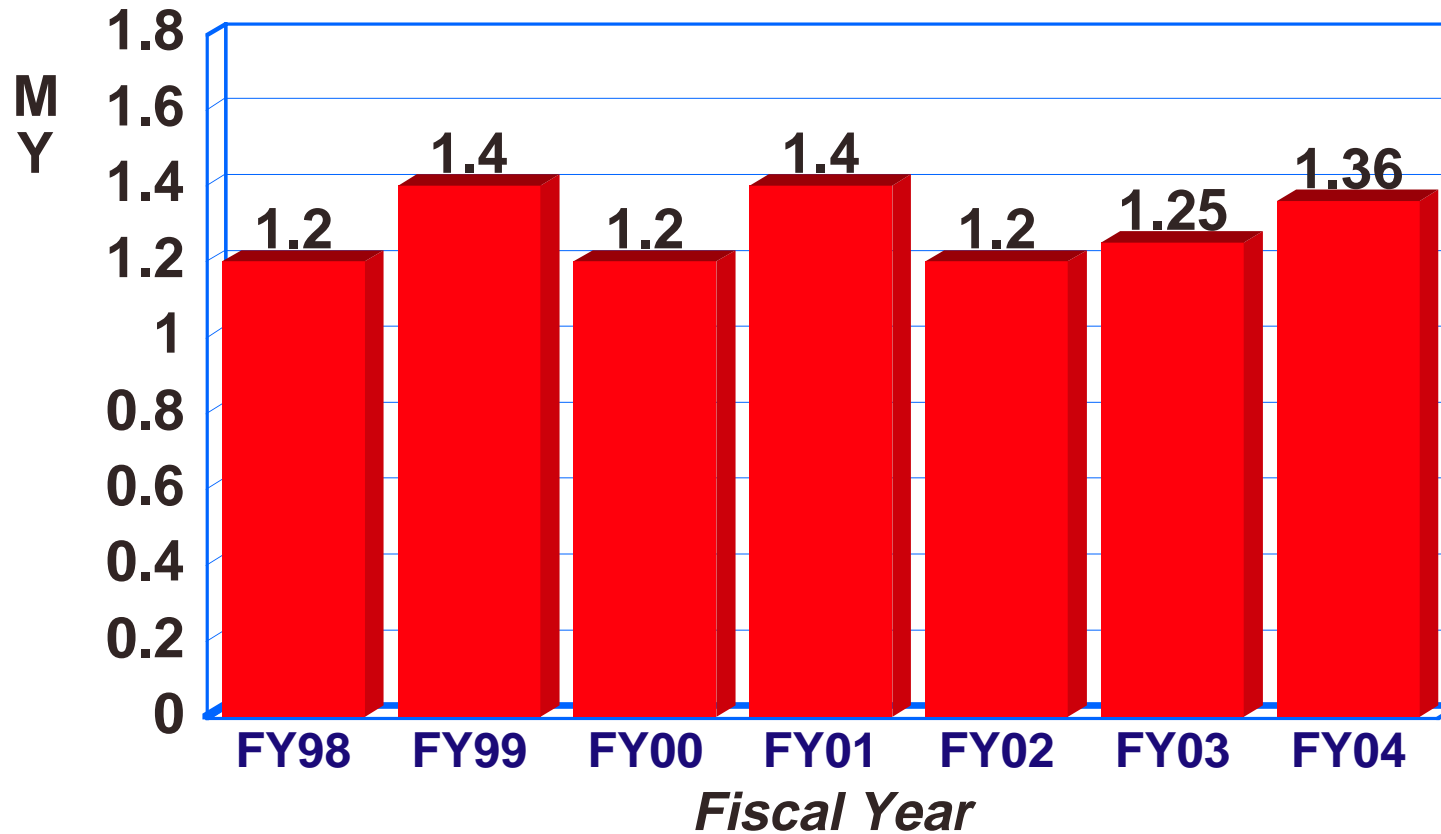
Calorimeter Trig. Cost Drivers





Peak Engineering Level

Calorimeter Trigger *WBS 3.1.2*



■ Wisconsin

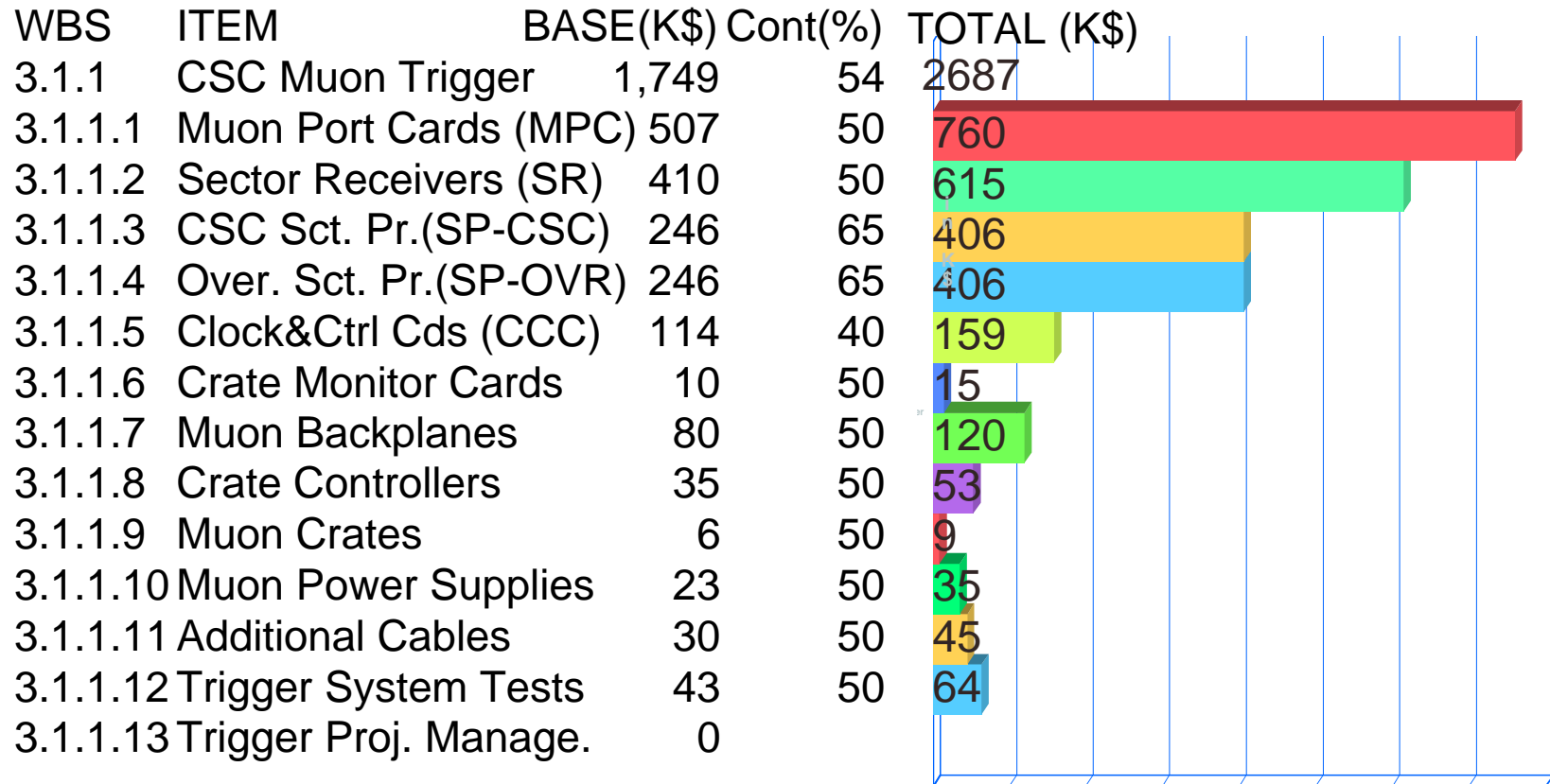


Cal.Trig. - 3.1.2 Milestones

	WBS	Task Name	1997		1998		1999		2000		2001		2002		2003		2004								
			Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr							
218	3.1.2.0.1	Start Prototype Boards			◆	1 Oct																			
219	3.1.2.0.2	Begin ASIC Development			◆	1 Oct																			
263	3.1.2.0.3	Internal Design Review 1					◆	11 Nov																	
264	3.1.2.0.4	Prototype Design Finished						◆	24 Jun																
265	3.1.2.0.5	Internal Design Review 2							◆	7 Oct															
266	3.1.2.0.6	Proto. Boards & Tests Finished								◆	11 Nov														
267	3.1.2.0.7	Begin ASIC Preproduction									◆	25 May													
289	3.1.2.0.8	Begin Backplane & Crate Production										◆	23 Mar												
290	3.1.2.0.9	ASIC Development Complete											◆	4 May											
291	3.1.2.0.10	Finish ASIC Preproduction												◆	24 Aug										
318	3.1.2.0.11	Begin Trigger Board Production													◆	28 Jan									
328	3.1.2.0.12	Begin ASIC Production														◆	28 May								
329	3.1.2.0.13	Crate & Backplane Complete															◆	22 Jul							
330	3.1.2.0.14	Begin Production Board Tests																◆	4 Nov						
358	3.1.2.0.15	Designs Finished																	◆	1 Mar					
359	3.1.2.0.16	Finish ASIC Production																		◆	13 Sep				
360	3.1.2.0.17	Finish Trigger Board Production																			◆	6 Dec			
361	3.1.2.0.18	Finish Production Board Tests																				◆	8 Apr		
373	3.1.2.0.19	Begin Trigger Installation																					◆	9 Apr	
374	3.1.2.0.20	Trigger Installation Finished																						◆	10 Oct



Muon Trigger Costs at L5

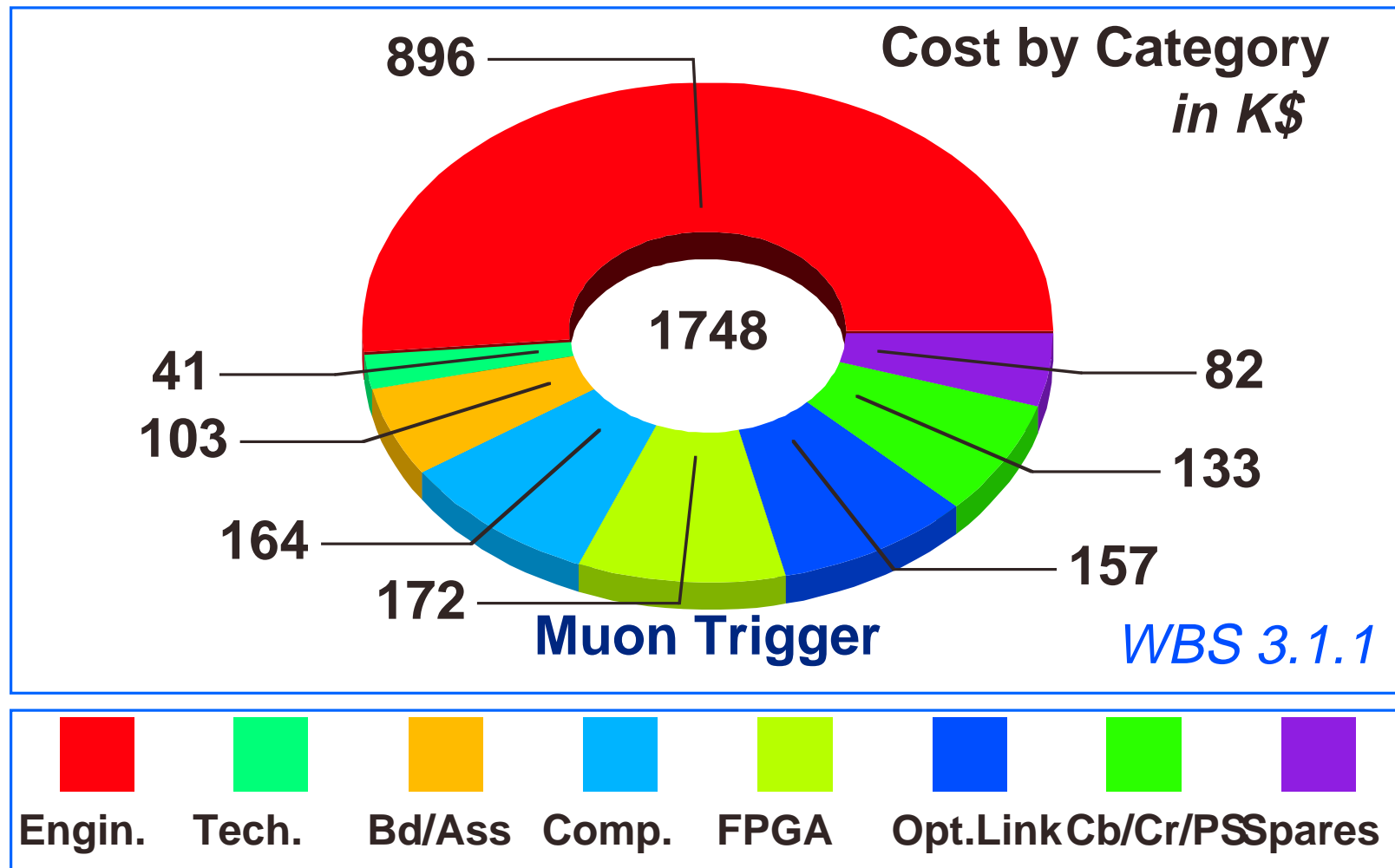


Changes since May 1998 Review (above) -- net cost difference < 100K:

- On-Chamber Trigger Electronics moved to crates on iron disk periphery
- Reorganization of Detector Crates for ME1/1A split strips
- Redesign of Counting House Crates for new interface with Drift Tube trigger
- New design of Track-Finding in the overlap region



Muon Trigger Cost Drivers

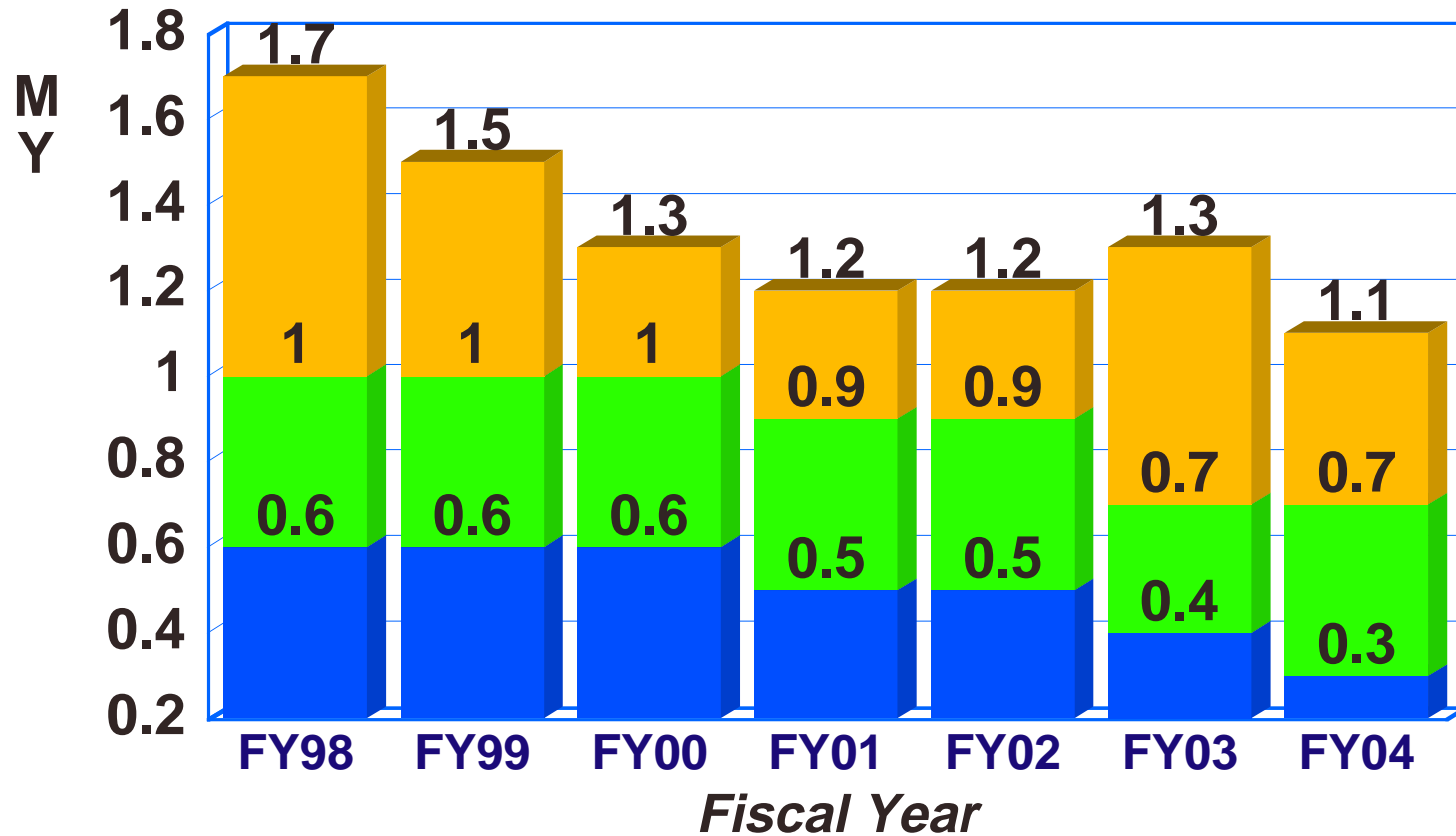




Peak Engineering Level

Muon Trigger

WBS 3.1.1





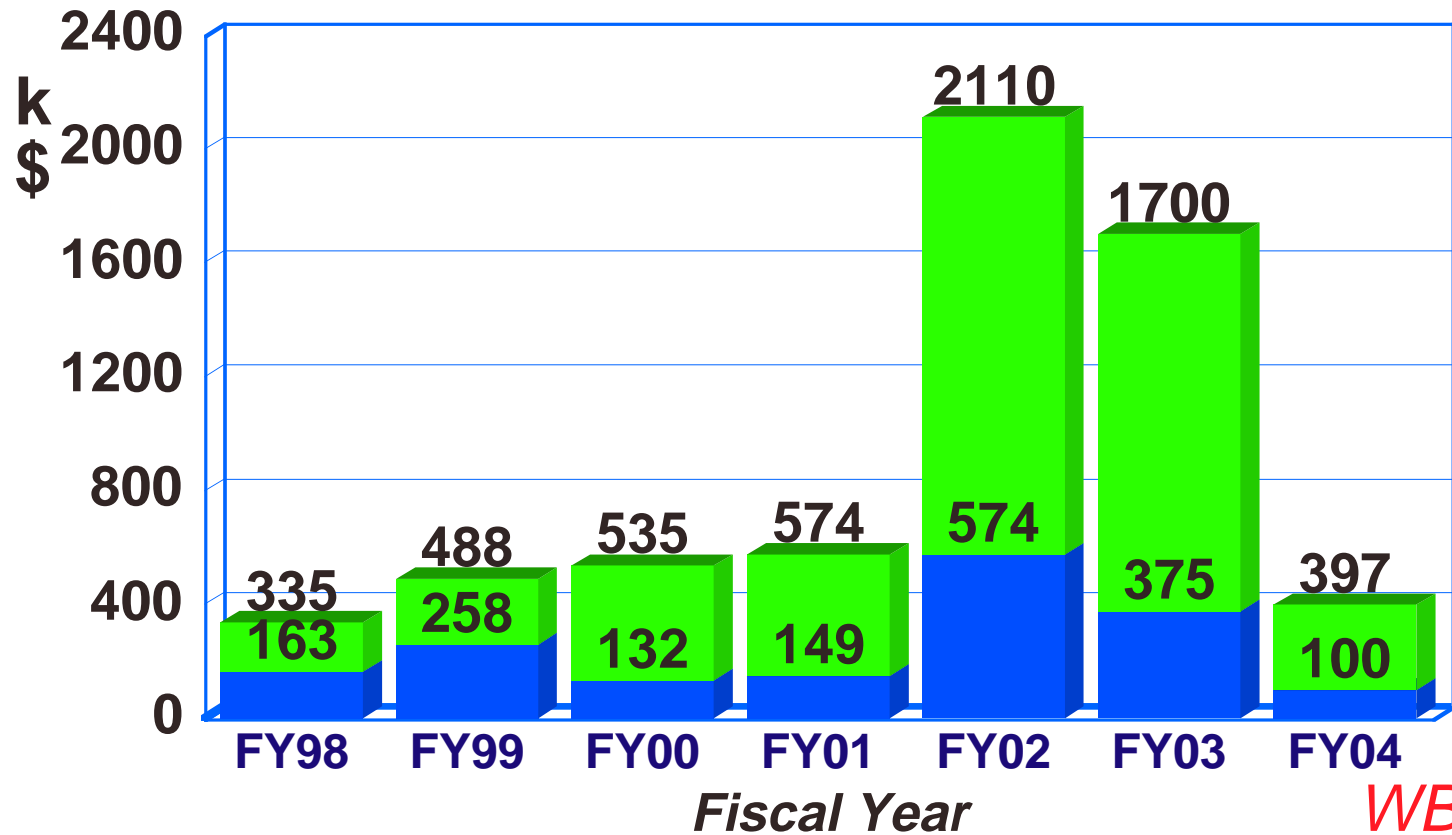
Muon Trig. - 3.1.1 Milestones

	WBS	Task Name	1997		1998		1999		2000		2001		2002		2003		2004		2005	
			Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr
153	3.1.1.0.1	⊕ Begin Initial System Design			◇ 1 Oct															
157	3.1.1.0.2	⊕ Finish Initial System Design	4 Feb	◇◇	13 May															
161	3.1.1.0.3	⊕ Begin Prototype Design	4 Feb	◇◇	13 May															
165	3.1.1.0.4	⊕ Finish Prototype Design			1 Apr	◇◇	22 Jul													
169	3.1.1.0.5	⊕ Begin Prototype Construction			1 Apr	◇◇	13 May													
173	3.1.1.0.6	⊕ Finish Prototype Construction			19 Aug	◇◇	9 Dec													
177	3.1.1.0.7	⊕ Begin Prototype Test			19 Aug	◇◇	30 Sep													
181	3.1.1.0.8	⊕ Finish Prototype Test			21 Apr	◇◇	23 Jun													
185	3.1.1.0.9	⊕ Begin Final Design			14 Apr	◇◇	9 Jun													
189	3.1.1.0.10	⊕ Finish Final Design							7 Sep	◇◇◇	15 Apr									
193	3.1.1.0.11	⊕ Begin Production							7 Sep	◇◇◇	15 Apr									
197	3.1.1.0.12	⊕ Finish Production										20 May	◇◇	19 Aug						
201	3.1.1.0.13	⊕ Begin Installation										20 May	◇◇	19 Aug						
205	3.1.1.0.14	⊕ Finish Installation												7 Oct	◇◇◇	1 Apr				
209	3.1.1.0.15	⊕ Begin Trigger System Tests															◇ 2 Apr			
213	3.1.1.0.16	⊕ Finish Trigger System Tests																		◇ 30 Sep



Obligations Profiles - I

Obligations for Muon & Cal Triggers



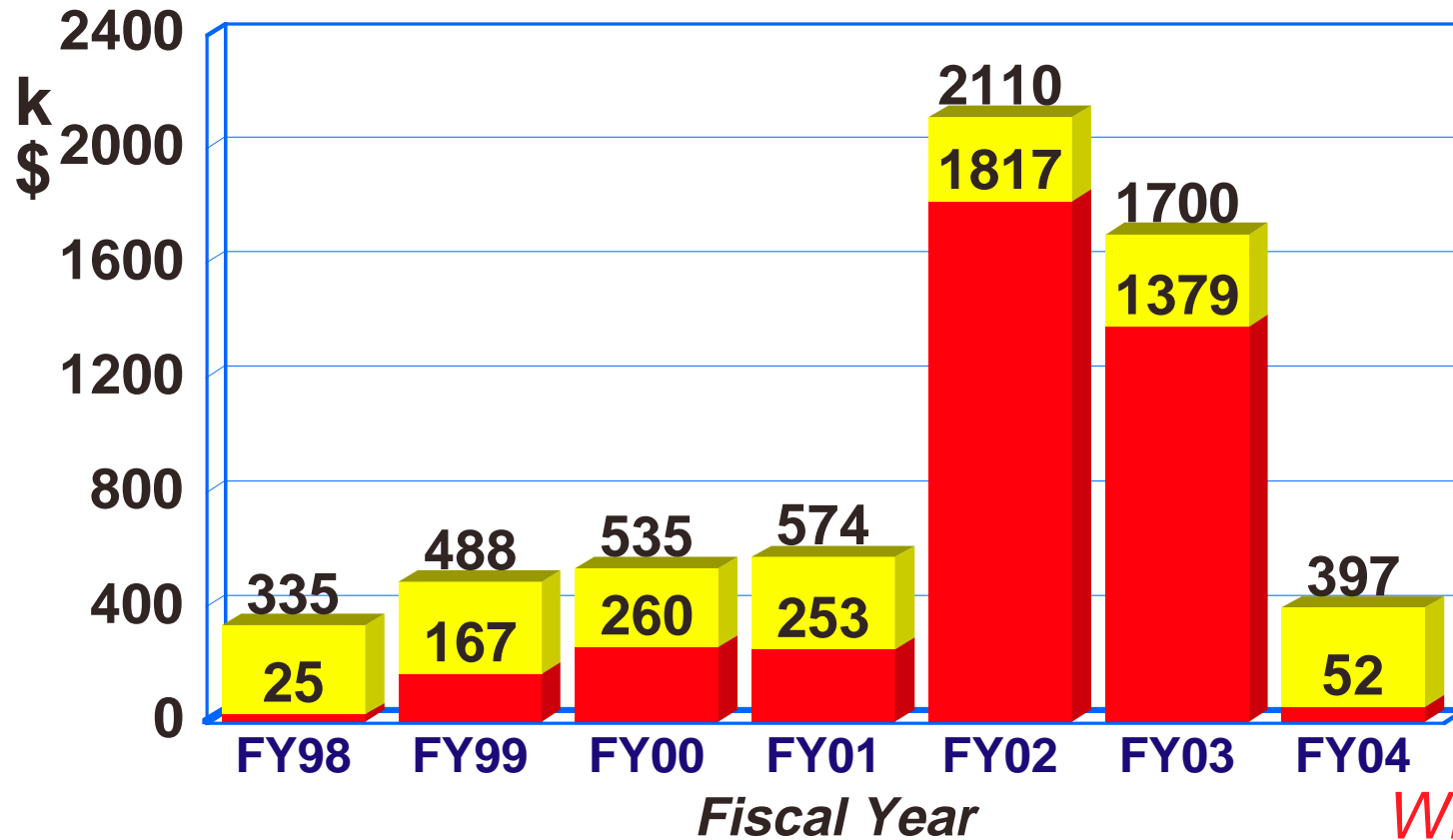
WBS 3.1





Obligations Profiles - II

Trigger M&S and EDIA Obligations





Trigger Project Management

CMS Annual Reviews

- **April: TriDAS Status**
 - Progress, draft R&D plans & expenses for next year
- **November: TriDAS Internal Review**
 - R&D Plans/Progress, Cost & Schedule, Milestones
 - Finalize R&D plans & expenses for next year
 - Internal CMS Review w/CMS and non-CMS referees (M. Campbell)
- **Internal Electronics Reviews by LHC Electronics Board CMS Reps.**
 - G. Hall (Imperial), G. Stefanini (CERN), J. Elias (FNAL) for W. Smith
 - Reports to CMS Management Board (last review in Fall '98)

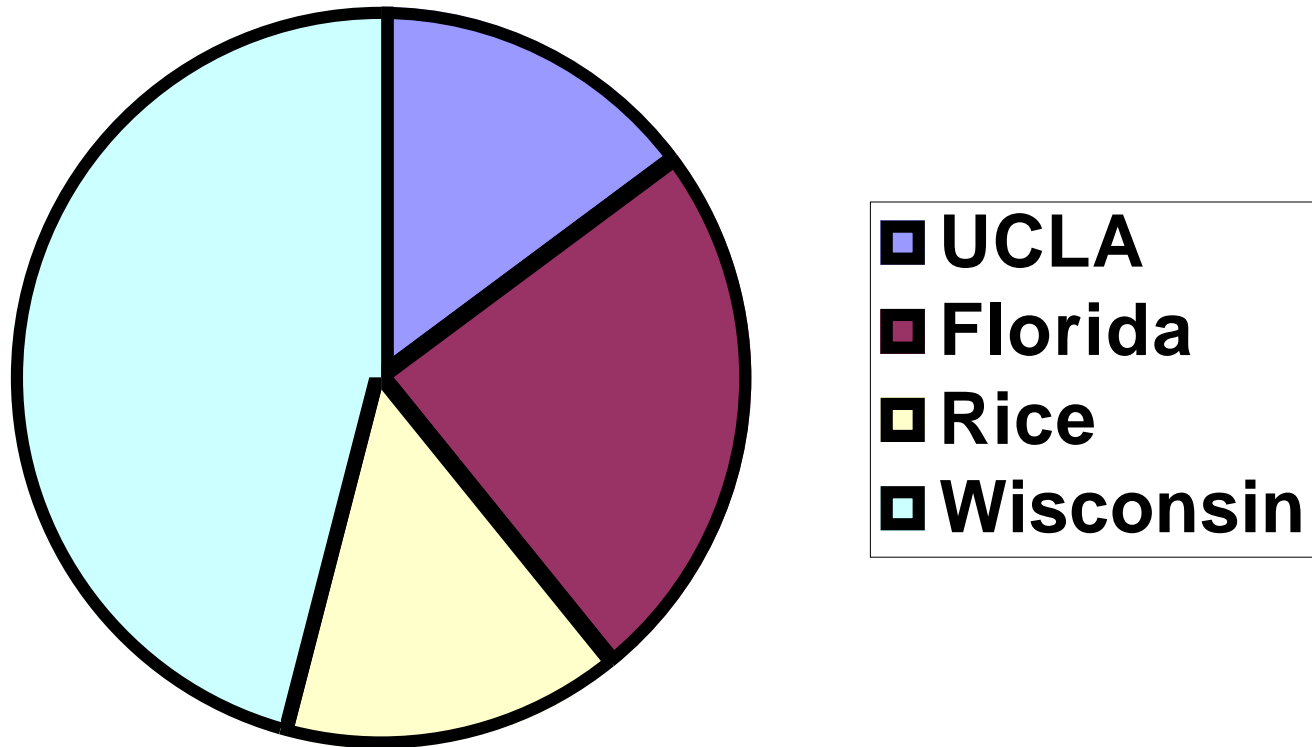
US Reviews/Reporting

- **Monthly Video Conferences:**
 - Florida, Rice, UCLA, Wisconsin, Davis (sim)
 - Review Progress, milestones, simulation activities
- **Integration Meetings:**
 - Calorimeter Trigger: FNAL, Maryland, Wisconsin
 - Muon Trigger: Ohio, Florida, Rice, UCLA, Wisconsin, others.
- **Annual Site Visits:** Florida, Rice, UCLA



Statements of Work - FY99

**TRIGGER - SOW99
TOTAL = 496K**





Progress on Muon Trig. Milest.

WBS	Name	Finish	Text1	% Comp	1998		1999		2000		2001		2002		2003		2004					
					Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr				
3.1.1	CSC Muon Trigger	9/30/04	J. Hauser	10%	[Progress bar from Oct 1998 to Sep 2004]																	
3.1.1.0.1	Begin Initial System Design	10/1/97	J. Hauser	100%	[Completed]																	
3.1.1.0.1.1	Begin Initial MPC System Design	10/1/97	RICE	100%	[Completed]																	
3.1.1.0.1.2	Begin Initial SR System Design	10/1/97	UCLA	100%	[Completed]																	
3.1.1.0.1.3	Begin Initial SP System Design	10/1/97	FLOR	100%	[Completed]																	
3.1.1.0.2	Finish Initial System Design	5/13/98	J. Hauser	100%	[Completed]																	
3.1.1.0.2.1	Finish Initial MPC System Design	2/4/98	RICE	100%	[Completed]																	
3.1.1.0.2.2	Finish Initial SR System Design	3/4/98	UCLA	100%	[Completed]																	
3.1.1.0.2.3	Finish Initial SP System Design	5/13/98	FLOR	100%	[Completed]																	
3.1.1.0.3	Begin Prototype Design	5/13/98	J. Hauser	100%	[Completed]																	
3.1.1.0.3.1	Begin MPC Proto. Design	2/4/98	RICE	100%	[Completed]																	
3.1.1.0.3.2	Begin SR Proto. Design	3/4/98	UCLA	100%	[Completed]																	
3.1.1.0.3.3	Begin SP Proto. Design	5/13/98	FLOR	100%	[Completed]																	
3.1.1.0.4	Finish Prototype Design	7/22/99	J. Hauser	0%	[Not Started]																	
3.1.1.0.4.1	Finish MPC Proto. Design	4/1/99	RICE	0%	[Not Started]																	
3.1.1.0.4.2	Finish SR Proto. Design	5/13/99	UCLA	0%	[Not Started]																	
3.1.1.0.4.3	Finish SP Proto. Design	7/22/99	FLOR	0%	[Not Started]																	
3.1.1.0.5	Begin Prototype Construction	5/13/99	J. Hauser	0%	[Not Started]																	
3.1.1.0.5.1	Begin MPC Proto. Construction	4/1/99	RICE	0%	[Not Started]																	
3.1.1.0.5.2	Begin SR Proto. Construction	5/13/99	UCLA	0%	[Not Started]																	
3.1.1.0.5.3	Begin SP Proto. Construction	5/13/99	FLOR	0%	[Not Started]																	
3.1.1.0.6	Finish Prototype Construction	12/9/99	J. Hauser	0%	[Not Started]																	
3.1.1.0.6.1	Finish MPC Proto. Construction	8/19/99	RICE	0%	[Not Started]																	
3.1.1.0.6.2	Finish SR Proto. Construction	9/30/99	UCLA	0%	[Not Started]																	
3.1.1.0.6.3	Finish SP Proto. Construction	12/9/99	FLOR	0%	[Not Started]																	



Muon Trigger Plans

Muon Port Card - Rice

- Construct Prototype - Sep '99
- Test with Sector Receiver - Dec '99
- Test with Trigger Motherboard - Mar '00

Sector Receiver - UCLA

- Prototype Design Review - Mar '99
- Construct Prototype - Oct '99
- Test with Muon Port Card - Dec '99

Sector Processor - Florida

- Prototype Design Review - Mar '99
- Construct CSC Prototype - Oct '99
- Construct OVR Prototype - Dec '99

Crate Test - Jun '00

- Sector Receiver Prototype - UCLA
- Sector Processor CSC & Overlap Prototypes - Florida
- Backplane - UCLA
- Clock & Control Card - Rice



Progress on Cal. Trig. Milest.

WBS	Name	Finish	Text1	% Comp	1998		1999		2000		2001		2002		2003		2004							
					Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr						
3.1.2	Calorimeter Regional Trigger	9/30/04	W. Smith	8%																				
3.1.2.0.1	Start Prototype Boards	10/1/97	WISC	100%	Oct 1																			
3.1.2.0.2	Begin ASIC Development	10/1/97	WISC	100%	Oct 1																			
3.1.2.0.3	Internal Design Review 1	11/11/98	WISC	100%			Nov 11																	
3.1.2.0.4	Prototype Design Finished	6/24/99	WISC	0%			Jun 24																	
3.1.2.0.5	Internal Design Review 2	10/7/99	WISC	0%			Oct 7																	
3.1.2.0.6	Proto. Boards & Tests Finished	11/11/99	WISC	0%			Nov 11																	
3.1.2.0.7	Begin ASIC Preproduction	5/25/00	WISC	0%			May 25																	
3.1.2.0.8	Begin Backplane & Crate Production	3/23/01	WISC	0%				Mar 23																
3.1.2.0.9	ASIC Development Complete	5/4/01	WISC	0%				May 4																
3.1.2.0.10	Finish ASIC Preproduction	8/24/01	WISC	0%				Aug 24																
3.1.2.0.11	Begin Trigger Board Production	1/28/02	WISC	0%				Jan 28																
3.1.2.0.12	Begin ASIC Production	7/1/02	WISC	0%				Jul 1																
3.1.2.0.13	Crate & Backplane Complete	7/22/02	WISC	0%				Jul 22																
3.1.2.0.14	Begin Production Board Tests	11/4/02	WISC	0%				Nov 4																
3.1.2.0.15	Designs Finished	4/7/03	WISC	0%				Apr 7																
3.1.2.0.16	Finish ASIC Production	10/20/03	WISC	0%				Oct 20																
3.1.2.0.17	Finish Trigger Board Production	1/28/04	WISC	0%				Jan 28																
3.1.2.0.18	Finish Production Board Tests	2/25/04	WISC	0%				Feb 25																
3.1.2.0.19	Begin Trigger Installation	2/26/04	WISC	0%				Feb 26																
3.1.2.0.20	Trigger Installation Finished	8/30/04	WISC	0%				Aug 30																



Calorimeter Trigger Plans

Prototype Dataflow Tests - Jun '99

- 160 MHz Backplane
- Proto. Receiver Card
- Proto. Clock Card
- Proto. Electron ID Card

Serial Data Tests - Oct '99

- Serial Link Test Card

ASIC Design & Prototypes - Mar '00

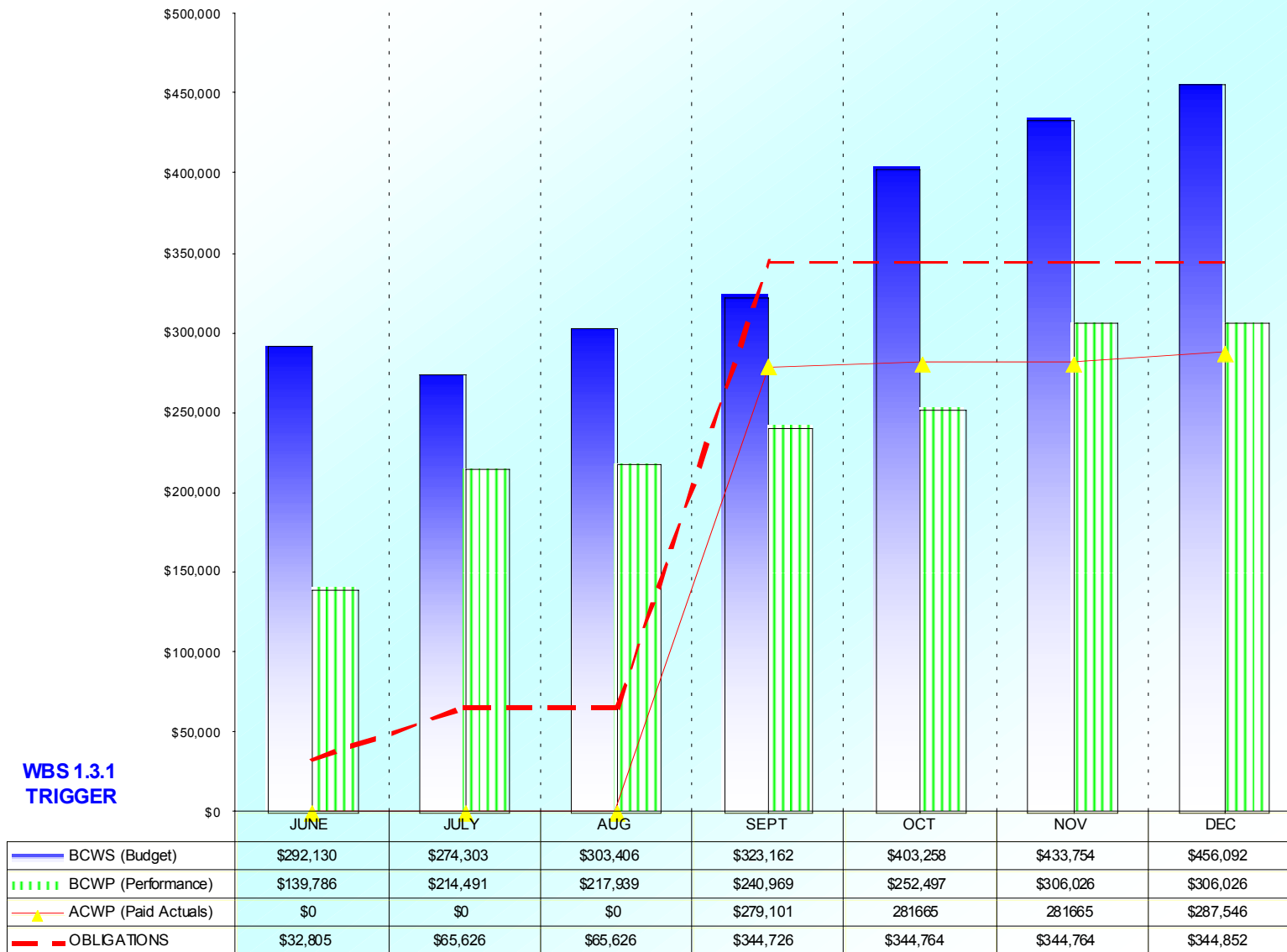
- Electron ID ASIC
- Phase ASIC
- Boundary Scan ASIC
- Sort ASIC

Crate Test - Jun '00

- 160 MHz Backplane
- Proto. Receiver Card
- Proto. Clock Card
- Proto. Electron ID Card
- Proto. Jet Summary Card

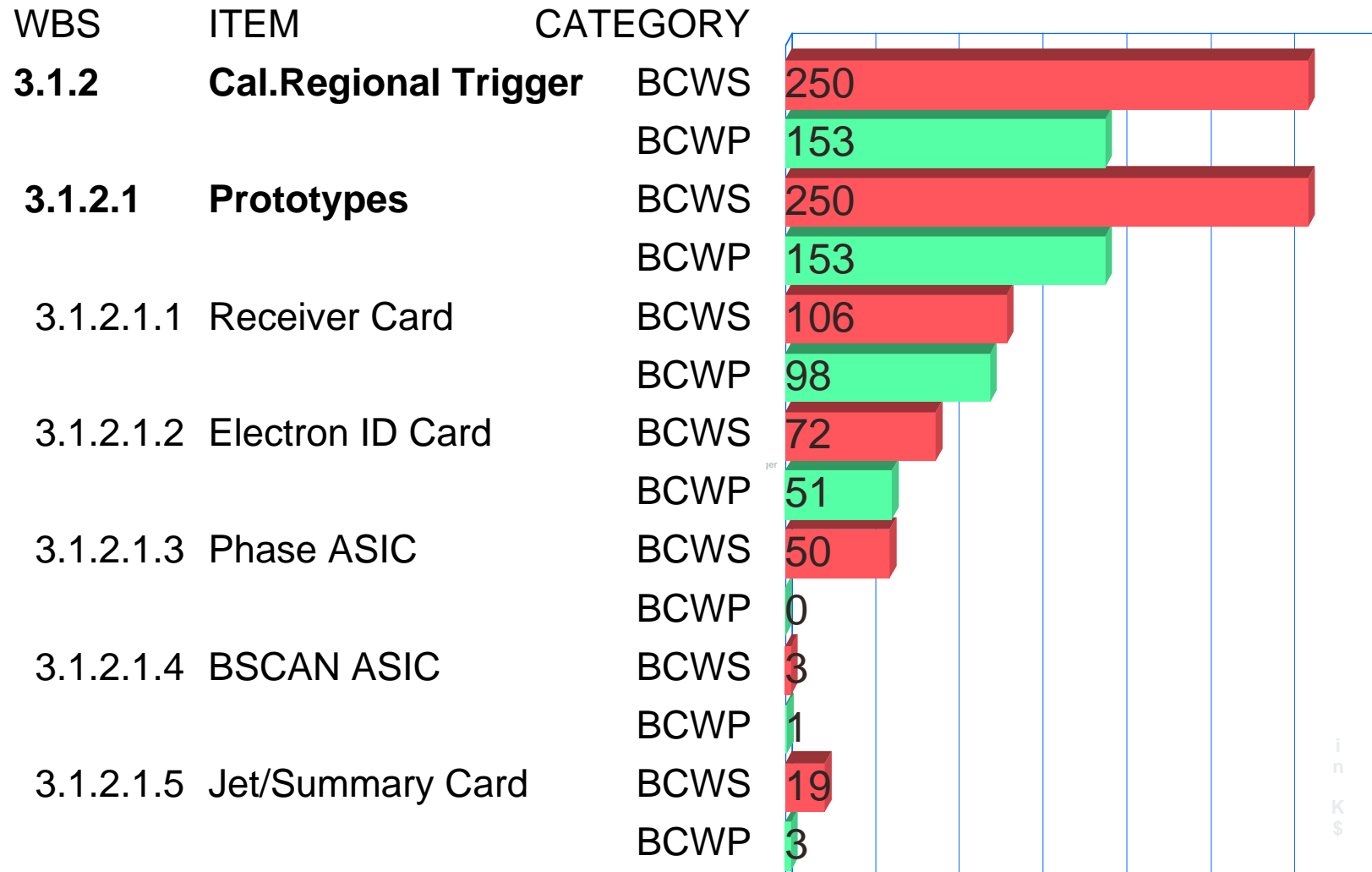


CPR - WBS 1.3.1, Trigger





Cal. Trig. L6 BCWP & BCWS



Shown for scheduled active tasks only for December '98



Issues - Calorimeter Trigger

1.2 Gb Serial Cu Link from H/ECAL to Regional Trigger

- Originally fibers from detector direct to trigger
- New CMS R&D effort to switch from fiber to wire to adjacent crates
 - Major improvement in access, environment, power, support
- Engineering load on Receiver Card project
- Moved Link to Mezzanine Card on Receiver Card
- Added 1 FTE EE from U.Wisc. PSL to work on this
 - New WBS for this task at cost < \$100K
 - This engineer also serves as reserve after Link done

Vendor Support

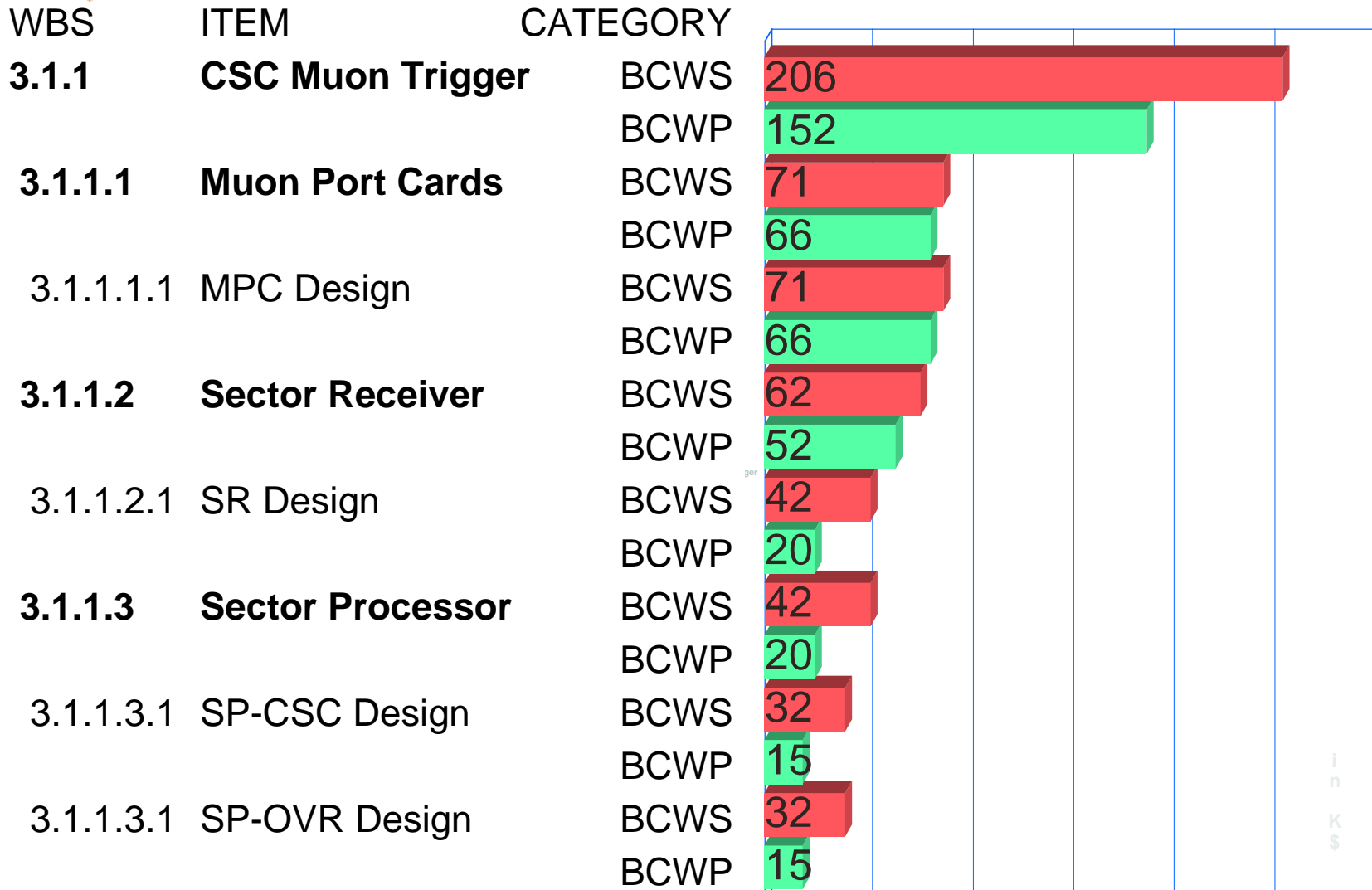
- Vitesse shifting to external ASIC engineering support
 - Experienced customers can still find internal support (small load)
- No Impact on ASIC production runs
- As per Lehman '98: contacting other vendors (AMCC, TriQuint, Fujitsu)

Final Algorithms & Tower Geometry

- Required for final designs of Boards, Backplane & ASICs
- Agreement on trigger tower geometry for HCAL & ECAL
- Agreement on final electron & jet algorithms
- Documents written & being circulated



Muon Trig. L6 BCWP & BCWS



Shown for scheduled active tasks only for December '98



Issues - Muon Trigger

Peripheral Crates

- Originally LCT circuitry on chambers connected to separate Port Cards
- Now all Strip & Wire LCT Boards, Mother Boards, Muon Port Cards moved to crates on the periphery of the iron disks
- Major improvement in access, environment, power, support
- Required full system redesign -- now complete
 - System redesign also handles ME1/1A split strips using added Muon Port Cards (48→60)

Overlap Region

- Both CSC & Drift Tube segments must be used for $0.9 < |\eta| < 1.2$
- Agreement reached with Barrel Muon groups (Vienna & Bologna):
 - 2 separate Track Finders with programmable sharp η boundary
 - Data sharing between Track Finders
- Requirement of separate sorter for CSC & DT muon tracks
 - Cost estimate $< 100K$
- New Conceptual design documents are being circulated
 - Design eliminates extra signal distribution & reduces crates (8→6) and sector receivers (48→24)



Cost & Schedule Performance

Important revisions result in an improved system

- Muon trigger move to peripheral crates
- Trackfinder integration w/ Drift Tubes & Global Muon Trig.
- Calorimeter trigger serial links to adjacent E/HCAL crates
- Cost in BCWP/BCWS (70%) is worthwhile investment

Actions taken to address schedule

- Additional engineer to work on cal. trig. serial link
 - application of contingency (100K)
- Working with Vitesse to resolve engineering
 - backstop of other vendors being put in place
- Redirection of effort on muon trig. Sector Receiver Card

Positive Developments that help schedule

- Muon trigger test beam results - can proceed as planned
- Receiver Card tests -- Adder ASIC may be used as is



Conclusions - Trigger

Good Progress Since May 98 Lehman Review

- **Extensive prototyping & test program**
 - "Proof of principle" of critical items
 - Number of successes already
 - Muon trigger test beam
 - Calorimeter trigger Receiver Card
- **Cost & Schedule Performance**
 - All Milestones made
 - Slippage in BWCP/BWCS
 - Slippage due to new designs now over with improved system
 - Actions taken to address schedule on other items
 - Positive developments also help
- **Project Management**
 - Extensive system of reviews and monitoring in place
 - Detailed documentation on WWW:
<http://cmsdoc.cern.ch/ftp/afscms/TRIDAS/html/level1.html>